

UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
OFFICE OF THE ADMINISTRATOR OF CIVIL AERONAUTICS
WASHINGTON 25, D. C.

TECHNICAL STANDARD ORDER

TSO-C10
January 2, 1948

SUBJECT: ALTIMETER, PRESSURE ACTUATED, SENSITIVE TYPE

INTRODUCTION

Sensitive altimeters are in the class of aircraft components which the Administrator of Civil Aeronautics is authorized to approve in accordance with Parts 03, 04 and 06 of the Civil Air Regulations.

In the establishment of this Technical Standard Order, consideration has been given to existing Government and industry standards for sensitive altimeters for the purpose of adopting the performance requirements of one of the recognized aeronautical standards as the minimum safety requirements for sensitive altimeters which are intended for use in civil aircraft. The specification of the Society of Automotive Engineers, Inc. for sensitive altimeters contains such requirements.

DIRECTIVE

Pursuant to Sections 03.06, 03.500, 04a.07, 04a.500, 04b.05, 06.05 and 06.500 of the Civil Air Regulations, which authorize the Administrator to approve aircraft equipment, the performance requirements for sensitive altimeters as set forth in,

* SAE Specification AS-392, Altimeter, Pressure Actuated
Sensitive Type, dated August 1, 1947,

are hereby established as minimum safety requirements for sensitive altimeters which are intended for use in civil aircraft.

The following alternate specifications also provide minimum performance requirements for sensitive altimeters which are satisfactory for use in civil aircraft as noted below:

Army-Navy:	AN-A-30-2	USAAF:	94-27424
	USAAF: 94-27409		94-27857
	94-27959A		

Any alternate specification listed above may be used in place of the basic specification. However, the requirements set forth in SAE Specification AS-392 are the minimum acceptable to the Civil Aeronautics Administration and shall be applicable in all cases wherein the performance provisions of the alternate specifications do not equal or exceed those requirements.

SPECIFIC INSTRUCTIONS

Marking. In addition to the identification information required in

Copies of the SAE specification listed above may be obtained from the following source: (Copies not available from the CAA.)

* SAE - Society of Automotive Engineers, Inc., 29 W. 39th St., New York, N.Y.

the referenced specification, each sensitive altimeter shall be permanently marked with the Technical Standard Order designation, CAA-TSO-C10, to identify the sensitive altimeter as meeting the requirements of this Order in accordance with the manufacturers' statement of conformance outlined below. This identification will be accepted by the Civil Aeronautics Administration as evidence that the established minimum safety requirements for sensitive altimeters have been met.

Data Requirements. None.

Effective Date. All new installations of sensitive altimeters in any civil aircraft used in instrument flight shall require sensitive altimeters complying with the terms herein effective July 1, 1948 for transport category aircraft and January 1, 1949 for all other aircraft. Individual aircraft having sensitive altimeters installed prior to this effective date may continue to use the older type instruments indefinitely, however, prior to the effective date, all sensitive altimeters installed in any civil aircraft used in instrument flight must be calibrated to the limits specified herein.

Deviations. Requests for deviation or waiver of the requirements of this Order, which affect the basic airworthiness of the component, should be submitted for approval by the Director, Aircraft and Components Service, Office of Safety Regulation, CAA. These requests should be addressed to the nearest Regional Office of the Civil Aeronautics Administration, Attn: Superintendent, Aircraft and Components Branch.

Conformance. The manufacturer shall furnish to the CAA, Aircraft and Components Service, Attn: A-298, Washington 25, D. C., a written statement of conformance signed by a responsible official of his company, setting forth that the sensitive altimeter to be produced by him meets the minimum safety requirements established in this Order. Immediately thereafter distribution of the sensitive altimeters conforming with the terms of this Order may be started and continued.

The prescribed identification on the sensitive altimeter does not relieve the aircraft manufacturer or owner of responsibility for the proper application of the sensitive altimeter in his aircraft, nor waive any of the requirements concerning type certification of the aircraft in accordance with existing Civil Air Regulations.

If complaints of nonconformance with the requirements of this Order are brought to the attention of the Civil Aeronautics Administration, and investigation indicates that such complaints are justified, the Administrator will take appropriate action to restrict the use of the product involved.

Copies of this Technical Standard Order and other technical standard orders may be obtained from the Civil Aeronautics Administration, Aviation Information Staff, Washington 25, D. C.



T. P. Wright

Administrator of Civil Aeronautics

ALTIMETER, PRESSURE ACTUATED
SENSITIVE TYPE

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1. **PURPOSE:** To specify minimum requirements for pressure actuated Sensitive Altimeters for use in aircraft the operation of which may subject the instrument to environmental conditions specified in Sec. 3.3.

2. **SCOPE:** This specification covers two types as follows:

Type I - Range 35,000 feet. Barometric Pressure. Scale range at least 28.1 - 30.99 inches of mercury (946 - 1049 millibars). May include markers working in conjunction with the Barometric Pressure Scale to indicate pressure-altitude.

Type II - Range 50,000 feet. Barometric Pressure. Scale range at least 28.1 - 30.99 inches of mercury (946 - 1049 millibars). May include markers working in conjunction with the Barometric Pressure Scale to indicate pressure-altitude.

3. **GENERAL REQUIREMENTS:**

3.1 **Materials and Workmanship:**

3.1.1 **Materials:** Materials shall be of a quality which experience or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.2 **Workmanship:** Workmanship shall be consistent with high-grade aircraft instrument manufacturing practice.

3.2 **Identification:** The following information shall be legibly and permanently marked on the units or attached thereto:

- a. Name of instrument
- b. SAE Spec AS 392
- c. Manufacturer's Part No.
- d. Manufacturer's Serial No. or date of manufacture
- e. Manufacturer's name and/or trade mark

3.3 **Environmental Conditions:** The following conditions have been established as design criteria only. Tests shall be conducted as specified in Secs. 5, 6, 7.

3.3.1 **Temperature:** When installed in accordance with the manufacturer's instructions, the units shall function over the range of ambient temperatures of -30C to 50C and shall not be adversely affected by exposure to temperatures of -65C to 70C.

3.3.2 **Humidity:** The units shall function and not be adversely affected when exposed to a relative humidity up to and including 95 per cent at approximately 32C.

- 3.3.3 Vibration: When installed in accordance with the manufacturer's instructions, the units shall function and shall not be adversely affected when subjected to the following vibration.

Frequency: 500 - 3000 cycles per minute
Amplitude: .010 inch
Maximum Acceleration: 0.8 g

Note: It is understood that the unit shall withstand vibration at higher frequencies but the acceleration value need not exceed that shown above.

When specified by the purchaser for use in rotary wing aircraft, the frequency range shall be 150 - 3000 cycles per minute.

- 3.3.4 Overpressure: The units shall not be adversely affected by exposure to a pressure of 50 inches of mercury absolute.

4. DETAIL REQUIREMENTS:

- 4.1 Indicating Method: The following method of indication shall be employed. For indicating an ascent in altitude the sensitive pointer shall move in a clockwise direction completing one revolution (360 degrees) for each 1000 feet of altitude change. A means shall be provided for showing the multiples of 1000 feet.

4.2 Dial Markings:

- 4.2.1 Increments: Markings shall be provided at intervals not exceeding 20 feet of altitude with major increment markings at 100 foot intervals.
- 4.2.2 Zero Setting System: A zero setting system shall be provided which will permit the Altimeter to be set to show field elevation at any existing ground level barometric pressure. The zero setting system shall show the barometric pressure in inches of mercury or millibars at sea level throughout the range of at least 28.1 to 30.99 inches (946 to 1049 millibars). A safety feature shall be provided which will prevent incorrect reading of the pressure scale when the zero setting mechanism exceeds its barometric pressure limits.
- 4.2.3 Finish: Unless otherwise specified, luminescent material (self-activating) shall be applied to the pointer(s), major graduations and numerals.
- 4.2.4 Name: The word "Altitude" shall be marked on the dial and may be in the same finish as the numerals.
- 4.3 Visibility: Pointers and dial markings shall be visible from any point within the frustrum of a cone, the side of which makes an angle of 30 degrees with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass shall be a practical minimum and shall not exceed 0.25 of an inch.

5. TEST CONDITIONS:

- 5.1 Atmospheric Conditions: Unless otherwise specified, all tests required by this specification shall be made at an atmospheric pressure of approximately 29.92 inches of mercury and at a temperature of approximately 22C. When tests are made with the atmospheric pressure or the temperature substantially different from these values, allowance shall be made for the variation from the specified condition.
- 5.2 Vibration (to minimize friction): Unless otherwise specified, all tests for performance may be made with the instrument subjected to a vibration of 0.002 to 0.005 inch amplitude at a frequency of 1500 to 2000 cycles per minute. The term amplitude, as used herein, indicates the total displacement from positive maximum to negative maximum.
- 5.3 Standard Pressures: The standard pressures used in calibrating the Altimeters shall be as specified in Tables III and IIIa.
- 5.4 Vibration Stand: A vibration stand shall be used which will vibrate at any desired frequency between 500 and 3000 cycles per minute and shall subject the instrument to vibration such that a point on the instrument case will describe, in a plane inclined 45 degrees to the horizontal, a circle, the diameter of which is equal to the amplitude specified herein.
6. INDIVIDUAL PERFORMANCE REQUIREMENTS: All instruments shall be subjected to whatever tests the manufacturer deems necessary to demonstrate specific compliance with this specification including the following requirements where applicable.
- 6.1 Calibration: For a period of not less than twelve hours prior to this test the Altimeter shall not have been operated at other than the pressures specified in section 5.1. The barometric pressure scale shall be set at 29.92 inches of mercury and the scale error recorded. Without changing the setting, the Altimeter shall be subjected successively to the pressures specified in Table I. The reduction in pressure shall be made at a rate of approximately 3000 feet per minute. The Altimeter shall remain at the pressure corresponding to each test point for at least one minute but not more than ten minutes before a reading is taken. The error at all test points shall not exceed the tolerances specified in Table I. The movement of the pointers shall be free from backlash and irregular motion when the pressure is changed uniformly.
- 6.2 Case Leak: A pressure equivalent to 18,000 feet within the case shall not result in leakage exceeding the tolerance shown in Table II during a period of 10 seconds.
- 6.3 Position Error: The change in pointer indication with change in instrument position shall not exceed the tolerance specified in Table II.
- 6.4 Barometric Scale Error: With the ambient pressure constant at 29.92 inches of mercury, various settings of the barometric pressure scale within its range shall cause the pointer to indicate the equivalent altitude as shown in Table III within a tolerance of 25 feet.
7. QUALIFICATION TESTS: As many instruments as deemed necessary to demonstrate that all instruments will comply with the requirements of this section shall be tested in accordance with the manufacturers' recommendations.

- 7.1 Low Temperature: The instrument shall be exposed to a temperature of -30C for 3 hours and while at this temperature shall meet the requirements of section 6.1 within the tolerances specified in Table I.
- 7.2 Extreme Temperature Exposure: The instrument shall, after alternate exposures to ambient temperatures of -65C and 70C for periods of 24 hours each and a delay of 3 hours at room temperature following completion of the exposure, meet the requirements of Section 6.1. There shall be no evidence of damage as a result of exposure to the extreme temperatures specified herein.
- 7.3 Hysteresis: Not more than 15 minutes after the Altimeter has been first subjected to the pressure corresponding to the upper limit of the scale in section 6.1 the pressure shall be increased at a rate corresponding to a decrease in altitude of approximately 3,000 feet per minute until the pressure corresponding to 20,000 feet is reached. Within 10 seconds the instrument shall indicate within 100 feet of the test reading. The Altimeter shall remain at this pressure for at least five minutes but not more than 15 minutes before the test reading is taken. After the reading has been taken, the pressure shall be further increased at the above rate until the pressure corresponding to 20,000 feet is reached. The Altimeter shall remain at this pressure for at least one minute but not more than ten minutes before the test reading is taken. After the reading has been taken, the pressure shall be further increased at the above rate until atmospheric pressure is reached. The reading of the Altimeter at either of the two test points shall not differ from the reading of the Altimeter for the corresponding altitude in the scale error test by more than the tolerance specified in Table II.
- 7.4 After Effect: Not more than five minutes after the completion of the hysteresis test, the pointers shall have returned to their original reading, corrected for any change in atmospheric pressure within the tolerance specified in Table II.
- 7.5 Vibration: The instrument shall be vibrated at 500 cycles per minute so that a point on the case will describe a circle of .003 - .005 inch diameter. The frequency shall be slowly increased to 3000 cycles per minute and then slowly decreased to 500 cycles per minute, to determine whether the natural frequency of the instrument is in this range. The drift of the pointer shall not exceed 50 feet and it shall not oscillate more than 20 feet. After three hours exposure to the vibration amplitude specified in section 3.3.3 and at the natural frequency (if between 500 and 3000 cycles per minute) or at 2000 cycles per minute the instrument shall meet the requirements of Section 6. No damage shall be evident after this test.
- 7.6 Magnetic Effect: The magnetic effect of the Altimeter shall be determined in terms of the deflection of a free magnet approximately 1-1/2 inches long in a magnetic field with a horizontal intensity of 0.18 ± 0.01 gauss, when the indicator is held in various positions on an east-west line with its nearest part five inches from the center of the magnet. (An aircraft Compass with the compensating magnets removed therefrom may be used as the free magnet for this test.) The maximum deflection of the magnet shall not exceed 1 degree for any pointer deflection.

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- 7.7 Humidity: The instrument shall function and not be adversely affected when exposed to the extreme condition specified in paragraph 3.3.2 for a period of 10 hours.
- 7.8 Overpressure: After being subjected momentarily to an absolute pressure of 50 inches of mercury the pointers shall return to their original reading, corrected for any change in atmospheric pressure, within 30 feet. Complete recovery shall have been effected in not more than 30 minutes after the pressure application.

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ALTIMETER, PRESSURE ACTUATED
SENSITIVE TYPE-6-
TABLE I

ALTIMETER SCALE ERRORS

Standard Altitude	Equivalent Pressure		Tolerance, Feet Plus or Minus	
	Mercury			
	MM	IN	Room Temp. Sec. 6.1	Low Temp. Sec. 7.1
0	760.0	29.92	20	75
500	746.4	29.39	20	
1,000	732.9	28.86	20	
1,500	719.7	28.33	25	
2,000	706.6	27.82	30	
3,000	681.1	26.81	30	
4,000	656.3	25.84	35	
6,000	609.0	23.98	40	130
8,000	564.4	22.22	60	
10,000	522.6	20.58	80	
12,000	483.3	19.03	120	230
14,000	446.4	17.57	140	
16,000	411.8	16.21	160	
18,000	379.4	14.94	180	340
20,000	349.1	13.75	200	
22,000	320.8	12.63	340	
25,000	281.9	11.10	375	500
30,000	225.6	8.88	450	
35,000	178.7	7.04	525	700
40,000	140.7	5.54	600	
45,000	110.8	4.36	675	
50,000	87.3	3.44	750	1000

TABLE II

Tests	Reference Section	Tolerance, Feet, Plus or Minus	
		TYPE I 35,000	TYPE II 50,000
Case Leak	6.2	100	100
Position Error Test	6.3	20	20
Hysteresis	7.3		
First test Point 25,000		70	150
Second test Point 20,000		70	150
After Effect Test	7.4	50	60

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TABLE III-a

Altitude-Pressure Table - Feet vs. Inches of Mercury

P inches	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
28.0	1824	1814	1805	1795	1785	1776	1766	1756	1746	1737
28.1	1727	1717	1707	1698	1688	1678	1668	1659	1649	1639
28.2	1630	1620	1610	1601	1591	1581	1572	1562	1552	1542
28.3	1533	1523	1513	1504	1494	1484	1475	1465	1456	1446
28.4	1436	1427	1417	1407	1398	1388	1378	1369	1359	1350
28.5	1340	1330	1321	1311	1302	1292	1282	1273	1263	1254
28.6	1244	1234	1225	1215	1206	1196	1186	1177	1167	1158
28.7	1148	1139	1129	1120	1110	1100	1091	1081	1072	1062
28.8	1053	1043	1034	1024	1015	1005	995	986	976	967
28.9	957	948	938	929	919	910	900	891	881	872
29.0	863	853	844	834	825	815	806	796	787	777
29.1	768	758	749	739	730	721	711	702	692	683
29.2	673	664	655	645	636	626	617	607	598	589
29.3	579	570	560	551	542	532	523	514	504	495
29.4	485	476	467	457	448	439	429	420	410	401
29.5	392	382	373	364	354	345	336	326	318	308
29.6	298	289	280	270	261	252	242	233	224	215
29.7	205	196	187	177	168	159	149	140	131	122
29.8	112	103	94	85	75	66	57	47	38	29
29.9	20	10	+1	-8	-17	-26	-36	-45	-54	-63
30.0	-73	-82	-91	-100	-110	-119	-128	-137	-146	-156
30.1	-165	-174	-183	-192	-202	-211	-220	-229	-238	-248
30.2	-257	-266	-275	-284	-293	-303	-312	-321	-330	-339
30.3	-348	-358	-367	-376	-385	-394	-403	-412	-421	-431
30.4	-440	-449	-458	-467	-476	-485	-494	-504	-513	-522
30.5	-531	-540	-549	-558	-567	-576	-585	-594	-604	-613
30.6	-622	-631	-640	-649	-658	-667	-676	-685	-694	-703
30.7	-712	-721	-730	-740	-749	-758	-767	-776	-785	-794
30.8	-803	-812	-821	-830	-839	-848	-857	-866	-875	-884
30.9	-893	-902	-911	-920	-929	-938	-947	-956	-965	-974
31.0	-983	-992	-1001	-1010	-1019	-1028	-1037	-1046	-1055	-1064

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TABLE III-b

Altitude-Pressure Table - Feet vs. Millibars

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